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May 24, 1935.

~~Working Plan~~*

NATURAL REPRODUCTION OF PONDEROSA PINE

Purpose

The general purpose of the study of natural reproduction of ponderosa pine in central Idaho is to determine the reasons for the great scarcity of subsequent reproduction on cutover areas in recent years and for the lack of advance reproduction on certain portions of virgin forest areas. It is evident from past studies either that some modification of cutting practice to encourage the establishment of more subsequent seedlings is required or that something should be done to facilitate more complete stocking of advance reproduction in the virgin stand. Without further knowledge of the factors controlling reproduction no one can say what these practices should be.

Scope

A comprehensive study of the whole problem seems to be called for. Naturally it will be built upon our present knowledge of the local situation and the results of rather intensive studies in other regions. It will place our general observations and guesses upon a more secure quantitative basis, and will eventually bridge the gaps between the disconnected facts that are now known and correlate all parts into a clearer picture, from which reliable conclusions may be drawn. Emphasis will be placed at first upon those phases of the problem that appear to be most critical and those which can most advantageously be attacked

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*See also preliminary plan of April 17, 1935 for a general presentation of the problem and proposed methods of study.

in 1935 and 1936 with the facilities and personnel available.

The following factors should make up the main divisions of any study of natural reproduction, namely: seed, seedbed, germination, survival, and growth. Based upon differences in field procedure as well as natural divisions of subject matter, those phases of the study to be undertaken in 1935 are outlined under the headings:

I. Seed production.
II. Seed distribution.
III. Factors affecting germination, survival, and growth.
IV. Measurement of germination, survival, and growth in natural stands.

The specific purpose, scope, and method of study are described for each phase or "sub-project".

I. Seed Production

The proposed study of seed production duplicates to a considerable degree studies of the same subject made in other regions, particularly the Southwest. It seems unavoidable, however, as this is essentially a local question which has never been adequately answered in central Idaho. The other studies are most useful in suggesting leads and methods and in providing results for comparison that should materially reduce the scale of the study and the time expended upon it.

The plan of procedure is predicated upon the belief that potential seed supply and its variations may be roughly estimated from relatively simple information about a stand -- probably only the size and Dunning class of each tree. The extreme variation of individual trees and of localities, with and without any apparent reason, is realized, but

sufficient definite relations have been demonstrated that it is still hoped to derive usable averages. The purpose is therefore to measure seed production of various forms and classes of trees and the annual variation thereof. A fair check of seed production upon an area as well as a tree basis will be provided by the examination of plots representing a wide variety of virgin and cutover stands.

Methods

The procedure is outlined under three main headings: A. Annual plot examination, B. Cone collections, and C. Cone development. The three are closely interrelated but involve varying kind and intensity of technique.

A. Annual Plot Examination. A tally of current cone crops will be made each fall on the following permanent sample plots:

Plot Numbers	Area	Location	Treatment
2, 6 (?)	20 A.	Pine Creek, B.B.E.F.	Selectively cut, 1933.
8	10	Bannock Creek, "	Virgin, to be estb.1935.
1	2	Clear Creek, Boise N.F.	Selectively cut, 1925.
3 plots, to be selected	15	Big Pine Cr. Payette N.F.	Virgin
1, 2, 3	13.87	Carpenter Cr. "	Selectively cut, 1913.
18	2.45	Crawford R.S. "	" " 1925.
2	2	Rock Flat, Idaho N.F.	" " 1925.
1-10	20 ?	Buckskin-Ophir Cr.	"Fire damage plots" virgin forest, burned 1931. Have 2 years' cone records.
- -	2	Slaughterhouse Gulch, B.B.E.F.	"Second growth" plots, to be estb. one in fairly dense, one in very open stand.

Plot Numbers	Area	Location	Treatment
Possibly to be selected	?	Weiser N.F. plots 1-5	Selectively cut.
1	4	Ditch Creek, Salmon F.G.	Selectively cut, 1908.
?	?	Other virgin forest areas on central Idaho forests, in connection with reproduction transects (see p.____)	

Record will be made of current cone crop on each tree of such size and character as might produce cones. Classes of size of cone crop will be defined after a preliminary field examination; they may be designated in the usual manner (none, light, medium, etc.) but should be reducible to an approximate specific number of cones. An estimate of past seed production, as evidenced by old cones on the ground, will be noted where it is feasible and reasonable to do so (probably four broad classes: none, light, medium, heavy).

Except for the selected trees mentioned later, it is tentatively proposed that no additional data on crown size, exposure, etc., be recorded. If such supplementary information is later found necessary to a satisfactory analysis and interpretation of the cone data it may then be noted.

A complete count (as nearly as can be made by general inspection) should be made of each current year's cones on a total of about 50 selected trees on the plots, representing a good variety of sizes and classes of trees and of localities. The purpose of these counts is primarily to furnish a check on the more general estimates; they will also serve as a slightly more intensive measure of yearly and local variations, taking into account crown size, etc. In addition to the usual data noted for sample plot trees, measurements or estimates will be made

of crown width, length, area, and density, exposure to light, apparent vigor, and approximate age, and notation of any special defects or environmental conditions that might be thought to affect growth or seed production. The regular enumeration sheets for the plots (form 114) may be used for recording cone data for "ordinary" trees; a special form should be made up for the "selected" trees.

To determine the true average production and the variability in annual production of different sizes and classes of trees this phase of the study should be continued for ten years. This period should also give some idea of periodicity of seed years (if any) in this region, added to the information we already have. A much longer period would really be required for a true average of "periodicity", but it is hoped that meanwhile we may learn sufficient about the physiology and the climatic controls of seed production to avoid the necessity of an indefinite observational study.

The schedule as outlined may prove to be too heavy a load of recurring work, especially after the expiration of emergency employment. It is flexible, however, and any number of years' records on any plots will be usable, so it may be cut down later. A couple of years' trial should show where there may be unnecessary duplication. Specific provision should be made for it in each season's program, however, not leaving it to "spare time" or the whim of the investigator. Probably at least the plots on the Experimental Forest should continue to be examined indefinitely.

B. Cone Collections. The object of this phase of the study is to determine the yield in number of germinable seed of the entire cone crops of individual trees of specific sizes and classes. At the time of year when seeds are ripe but cones unopened, all the cones from chosen trees will be gathered, counted, dried, and the seed extracted and weighed. Samples of the seed from each tree will subsequently be weighed, counted, and tested for germinative energy.

Most of the cone collections will be made from trees felled in logging operations. The B.P.L. Co. cuttings and others in Long Valley will probably offer the best chance for a large number of trees felled within a short period of time. As the cone ripening season approaches, the area scheduled for cutting at the estimated time should be examined and suitable trees selected and numbered with crayon. Measurements and description of each tree, including ocular estimate of cone crop, will be recorded as prescribed above for "selected" trees. Probably a hundred trees should be noted, with the expectation that many of them can not be used later for individual cone collections for one reason or another. To obtain data for smaller trees or those of a character or location that are not being felled in logging, it will doubtless be necessary to fell a few trees for the purpose, or, where the cones are few or the trees small, to collect from standing trees.

The full range of sizes and classes of trees that may bear any seed at all should be sampled if possible. The number of individual collections to be made is difficult to prescribe as it may be limited by the short period when ripe cones remain closed and other factors -- a minimum of 50 is suggested for each year. It will probably be desirable to enlarge the

study crew for the job of actual collection as it must be done at just the right time and very promptly after felling.

Collections will be made in two different years, preferably in a year of light cone crop and another year of fair to heavy cone crop. It will not pay to attempt this phase of the study if the cone crop is very light or negligible, but it is also desirable to complete this part of the study as soon as possible. Whether 1935 and 1936 will be suitable remains to be seen. Two years' records will give some suggestion, though probably not a true measure of possible annual variation in such figures as seed per cone, seed per pound, and germinative energy for specific classes of trees. This particular phase of the study is so time-consuming, however, that it is believed its continuation over many years would not be justified by the value of results obtained.

Biotic relations. The prevalence of and losses by cone weevils should be measured in a rough way. In addition to general observations during the process of seed collection, extraction, and testing, five cones may be picked at random from those of each tree and examined in detail for weevil damage. Since it is known to vary widely with locality and season, this factor should also be investigated and noted in a general way if feasible on each of the areas sheduled for annual inspection. Some arrangement may have to be made with the squirrels to prevent their gathering cones from the trees scheduled for collections. (See also "Rodent Studies", p.____).

Seed testing. The details of procedure in germination tests, etc. will be prescribed at a later date. If possible the sample for each tree

should consist of 400 or more seeds. Sand flat tests can be carried on at Ogden or elsewhere during the winter.

The seed collections from various classes of trees may well be used in part for "genetical" studies (beyond the germination stage) which have been thought of in a tentative way, if such should be undertaken. Otherwise any surplus may be used for general planting or distribution purposes. If no such use is foreseen, it would be unnecessary to save all the cones from large trees in a good seed year -- only enough to provide liberally for germination tests.

C. Cone Development. A more exact knowledge of the progress through the season of flowering and fruiting of ponderosa pine and the factors (largely climatic) affecting it is essential to a full understanding of the whole problem, and would be of practical value in the prediction of seed crops a year or more in advance. A study of these functions is a part of the general schedule of phenological observations proposed for the Station. Assuming that the latter are initiated in the summer of 1935, it is necessary only to broaden their scope as related to this species.

Observations of phenological events (bud opening, pollen ripening, etc.) will presumably be made weekly, at least through the spring season when rapid changes are occurring. It is proposed that six specific ponderosa pine trees (of a size and character apparently able to bear a good crop of cones) be selected for such observations near headquarters and in Bannock Creek; 2 at about 4000', 2 at 5000', and 2 at 6000' elevation. Of each pair, one would be a distinctly open-growing specimen, the other

within a stand.

Beginning at flowering time a more intensive examination of these trees will be made about every two months to obtain a quantitative measure of flower production, cone-setting, and rate and cause of subsequent loss. The exact technique of such examination will have to be worked out in the field; the devising of an apparatus and system for inspecting the tips of branches on a tree crown without injury or undue disturbance calls for no little ingenuity. It may be impracticable to examine all the developing cones on a tree; possibly certain branches may be tagged for periodic inspection. In any event, different sides and levels of the crown should be sampled, and the scheme should be such that a rough reduction to total tree or to crown area basis can be made.

An attempt will be made to relate flower and cone development to records of current and precedent weather. As facilities become available and methods are devised, it will eventually be desirable to make this study even more fundamental, considering the physical and chemical changes that take place within the tree and its vegetative growth as well as reproductive functions. At such time the observations and measurements outlined above may be merged into the broader study as a distinct project.

II. Seed Distribution.

An attempt will be made to answer two main questions: (1)Of the potential seed supply how much seed reaches the forest floor; or, conversely, how much is destroyed and by what agencies? (2) How is it distributed over the area? Two lines of attack are proposed, which may

be designated as: A. Rodent studies, and B. Seed trap studies.

A. Rodent Studies. The importance of rodents (to a lesser extent, birds and other animals) in the reproduction of ponderosa pine has been repeatedly emphasized by various observers. Poisoning, trapping, and exclusion have been practiced in other regions with variable success and benefit to reproduction. Still relatively little is known about the rodent population of forest and cutover areas, their food preferences and feeding habits (especially as related to conifer seed), their reaction to environmental changes (as by cuttings or fire), their possible beneficial role, and their place in the general "balance of nature" -- all of which would seem fundamental to a scientific solution of the problem.

The study of rodent relations from this basic angle calls for the services of a trained biologist, possibly working for or under the general direction of the Biological Survey. To date the Survey has had a hard time getting enough properly qualified men and funds to handle their important game studies, and it is very doubtful whether we could even hope to have a man assigned to such an "incidental" study. Hence no comprehensive plan for a biological study is outlined at this time, but its desirability should be kept in mind and any opportunity to hire a competent man to carry on the study should be seized.

Meanwhile we shall attempt to measure the "net effect of rodents" by suitable exclosures, somewhat as has been done in other regions. Rodents are prevented from consuming the seed which falls in seed traps. We shall have no measure of quantity of cones or seed removed directly from the trees by rodents or birds other than the doubtful one of subtracting seed trap collection from theoretical supply for an area.

The destruction by rodents and other agencies of seed and seedlings on the forest floor will be measured roughly by a comparison of artificial seedings inside and outside of exclosures as described later (p._____). This is not really a satisfactory measure of extensive natural conditions but no way to accurately determine the latter is apparent at this time. One general difficulty in measuring rodent effects is that they are probably extremely variable from place to place.

B. Seed Trap Study. Seventy-five seed traps, each 3.3' x 3.3' (one quarter milacre) in size, will be placed at regular intervals over the area on selectively cut plots 2 and 6 on Pine Creek and virgin forest plot 8 on Bannock Creek. The remaining 25 traps now on hand will be placed on areas of young timber near B.B.B.S. headquarters or in special locations to be picked later. These traps will be inspected and seed counted and removed about four times per year: at the beginning of the field season in the spring, approximately May 1; just before seed ripening in late summer, approximately August 15; after main seed fall, approximately September 15; and at the end of the field season, approximately October 31. All seed collected should be subjected to a cutting test for apparent viability. It is not anticipated that enough will be obtained to make germination tests worth while.

The location of seed traps in relation to potential seed trees will be shown on plot maps and by notes. As the cone crops of plot trees will be noted each year, it may be possible to correlate to some extent number of seeds collected in the traps with total seed production within certain

zones or in certain directions.

Tentatively it is proposed to continue this phase of the study for five years or if necessary longer until at least one heavy seed crop has been produced. As now outlined the work is all centered at the B.B.B.S. and requires only a few man-days time each year. It may be desirable to increase the number of traps or to change their placement later.

The question of the possible extent and distribution of seed released from various heights in various velocities of wind is assumed to be satisfactorily answered by the experiments of Isaac, Siggins, and others.

III. Factors Affecting Germination, Survival, and Growth

Even where we know that a substantial quantity of seed reaches and remains on the forest floor, reproduction fails to develop in expected and desired numbers except in certain "favorable" years and "favorable" spots. Many seeds undoubtedly fail to germinate, and seedling losses are enormous during the first year and continue at a decreasing rate until ordinarily only a small fraction of the original number become "established". The key to the problem lies in determining what combinations of factors are inherent in these "favorable" times and places and what specific factors prevent the establishment of reproduction in the "unfavorable" places in this region. Knowing these limiting factors for given sites or localities, the forester may then be able to control the cutting and manage the forest in such a way as to create the desired conditions of shade, ground cover, or what not, and thus more nearly approach the ideal of prompt and complete regeneration.

Intensive studies by various investigators have contributed much to the knowledge of requirements of ponderosa pine seed and seedlings and of the limiting physical factors in other regions. They can not tell us what these limiting factors are in central Idaho. Much has also been learned from observation and preliminary studies by various workers in Idaho, but some basic questions are still unanswered. Further observation will help but may never give final answers because each set of conditions in nature is such a complex combination of environmental factors that the controlling ones are obscured, and also because precise instrumental measurements of these factors are required to detect differences not apparent to the senses.

The object and plan of the present study is thus: (1) to measure on selected natural sites those physical and biotic factors which appear to be most effective in limiting seedling establishment; (2) to modify and segregate the effect of certain factors by artificial measures of "semi-control"; and (3) to obtain an integrated measure of these site or factor differences in the significant terms of seed germination and of seedling survival and development in artificial plantings. For the sake of brevity, this will all be referred to as the "factor study".

Seed germination, seedling survival, and seedling growth may logically seem to be distinct subjects which should be treated separately, but in nature seedling development is a continuous process and several of the same factors affect all three stages. Here essentially the same experimental set-up covers all three. Hence in this outline of procedure they are included under the same heading; the features which apply specifically to each should be apparent.

Emphasis will be placed at first upon the direct factors of temperature (particularly soil surface temperature) and soil moisture, as these two are affected by differences in aspect (exposure), shade, litter cover, competing vegetation, and weather. The further effects of shade and of wind protection in reducing transpiration will be considered. Effect of rodents will be determined by exclosures as mentioned above.

Methods

(1) Three stations will be established, representing a north slope, south slope, and flat within a single forested drainage, presumably Bannock Creek. If possible each station should be in a broad opening, free from shade and root competition by trees. Slope should not be over about 30 percent, but should be sufficient to give typical north and south slope effects. Each site will be cleared of brush (grass or weeds may be left except in or near seedbeds), and a fenced enclosure, 30' x 60', will be constructed. Of the enclosure, three fourths (30' x 45') will be fenced with rodent-proof screen.

(2) Daily instrumental measurements of site factors

("weather readings") will be made at each station, as follows:

FACTOR	WHERE MEASURED	INSTRUMENT
Air Temperature	In shelter, 5' above ground	Thermograph (checked) Max.&Min. Thermometers
Wind Movement	2' above ground	Anemometer
Evaporation and Cumulative Insolation	½' above ground	Livingston porous-cup atmometers, paired black and white cups
Surface Temperature	At soil surface	Max. and min. gooseneck thermometers; current therms. for special obs.
Soil Temperature	6" and 12" depths	Current soil thermometers Soil thermograph for daily trends at surface, 6" and 12"; for short periods only (one inst.)
Periodic (weekly?) measurement of: Soil Moisture	½", 6", 12" depths	Sample cans; geotome (?).

(3) Readings should be made at least daily (8 a.m.) through the growing season. The basic records of all main factors at each station should if possible be maintained continuously through the season, particularly in the first year. Specific short-period studies, as of soil surface temperatures (see p. ___) will necessitate some temporary interchange of instruments and special schedules of observations.

Weekly readings of air and soil temperatures and possibly soil moisture will be made during the snowless but inactive periods in early spring and late fall (schedule of these and of winter readings, if any, will be planned in detail later).

(4) Seedling test beds.--At each station 21 seedbeds, each about 25" x 50", will be prepared, representing four surface (seedbed) conditions, two degrees of shading, effect of artificial watering, and effect of rodent exclusion, as follows:

Surfaces: 1. Natural bare mineral soil, undisturbed; seed uncovered.

2. Natural bare mineral soil, disturbed; seed planted in furrows.

3. Soil covered with ½" pine needle litter; seed not buried.

4. Soil covered with pine needle litter; seed planted in furrows in mineral soil.

Shade, Water and Rodent Series (four surfaces in each series):

A. Fully exposed to sunlight.

B. Fully exposed to sunlight; artificially watered.

C. Shaded from direct sunlight.

D. Shaded from direct sunlight; artificially watered.

E. Same as B, but outside rodent-proof exclosure.

One extra seedbed, shaded, natural soil surface, seed-covered, surface-watered through early germination period (?)--for root examinations or to supply replacement seedlings, etc.

Plots should also be designated from which to obtain soil moisture samples.

Space should be provided for at least 40 seedbeds at each station (which should be preserved from unnecessary trampling, etc.); they may not all be needed, but liberal allowance must be made for expansion, investigation of other factors, duplications, etc.

Seedbeds will lie flush with the general surface and on the natural slope of the ground, and should receive no more cultivation or disturbance than is included in the prescribed treatment.

(5) In each seedbed 1,000 ponderosa pine seeds of known local origin will be planted. On surfaces #2 and #4 of each series, these will be divided into 5 lots of 200 each, and planted with

approximate ½" spacing in rows about 2" apart. The five divisions may be separated by staked wires. On surfaces #1 and #3 seed should be broadcast as uniformly as possible. A space about 10" wide should be left unplanted along one end of each bed for taking of local soil moisture samples, placing of thermometers, etc. The date of first planting is tentatively set at October, 1935. Fall planting is desirable to simulate natural seeding and germination conditions; it has the disadvantage here that excessive rodent consumption, washing, etc., may occur through the winter when there is no current check on the plots.[1/]

[1/] This question of planting date suggests another line of study that might be followed up some time--a test of the course of germination of seed planted at various times under natural field conditions (possibly on various aspects and at different elevations). The results would perhaps be of academic rather than practical value, as man has no control over the time of natural seeding. Some useful hints might come from it, however.

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(6) Shaded beds.--The purpose of shading beds in series C and D is to preclude losses by direct heat injury from insolation and to reduce evaporation and transpiration to the extent that shading from direct sunlight may do so. This is not an attempt to measure

the effect of variation in light as such, and except for the exclusion of direct sunlight as much diffuse light should be admitted as possible. The beds should receive full precipitation and reasonably free air circulation. The exact arrangement of screens or devices to meet these requirements will have to be worked out in the field. The aim should be to simulate conditions such as might exist in a small opening in the forest, fully shaded from the sides, but without the effects of root competition. Full shade rather than part shade is prescribed in order to make the effect of this factor more decisive.

(7) Watered beds.--The object of watering beds of series B, D, and E is to segregate soil moisture from the other factors influencing germination, survival, and growth. Water will be applied by sprinkling cans at such times and in such quantities as to insure that moisture deficiency will not be a cause of lack of germination or of losses. The schedule of watering will be similar to that of seedbeds in a nursery. It may not be the same for all three sites but should maintain all watered beds in a comparable state of moisture.

(8) Seedling examinations.--Beginning with the first appearance of seedlings in the spring, an intensive count and inspection of seedlings should be made once a week and more frequently during periods of rapid germination or heavy losses. Thus when surface temperatures reach the danger point (above 120°F.) it will be desirable to examine certain beds for losses from this cause every day. Since it is one of the primary objects of the study to determine cause of deaths or injury, examinations should be frequent enough to deduce and note them with fair accuracy. Weeds will be removed as soon after they make their appearance as practicable.

At each inspection newly germinated seedlings will be counted and marked with toothpicks. For each succeeding 2-week period a different color of toothpick will be used. Dead seedlings will be tallied by cause of death and removed from the bed. Losses may be classed under:

1. Drought
2. Heat
3. Frost
4. Shade
5. Damping off
6. Insects
7. Rodents
8. Other biotic
9. Other
10. Unknown

Detailed notes will be made to amplify these or others which may be observed; also to record visible injuries not resulting in death.

(9) Growth of seedlings.--The heights of a sufficient number of surviving seedlings in each bed to obtain a good average and represent the range will be measured in the fall of the first season and again about July 1 and October 1 of the second and third seasons. Where only a few survivors remain in a bed it may be desirable to number them and keep individual growth records for the second and third seasons. Where there are striking differences between beds or locations, representative seedlings may be carefully dug out and photographed. If true and measurable differences are apparent at the end of the third year, and if the number of seedlings justifies it, more complete measurements of dimensions of tops and roots, including dry weight of each, may be made. If in the second or third year there are too many seedlings in certain beds to allow fairly free individual development they should be thinned out to some standard spacing (to be decided later). Information on growth of older seedlings will be

obtained from transect records and special studies of native seedlings (see p.___).

(10) Soil surface temperature.--During the periods when soil surface temperatures approach or exceed the danger point, supplementary measurements of this factor will be made to determine differences in the maximum temperature and duration of lethal temperatures on the three aspects and various seedbeds. The details of measurement, using gooseneck thermometers, current thermometers, and soil thermograph, will be worked out in the field.

(11) Soil moisture.--It is tentatively prescribed that determinations of soil moisture be made weekly and at depths of 0-½", 5-6", and 11-12". It may be desirable to take supplementary samples after heavy rains, and possibly to extend the period to every two weeks in late summer and fall. The surface samples are primarily to measure relations to germination; hence extra ones will be desired from the various beds early in the season, and few if any need be obtained later in the year. No samples need be taken from watered beds, unless

occasional ones are desired as a general check on the extent to which favorable moisture conditions are being maintained.

If and when seedling roots penetrate to depths greater than 12", soil moisture samples should also be taken regularly at sufficient depths (probably at 6" intervals) to measure all zones of root growth.

A more exact schedule of soil moisture sampling will be set up after the stations are established. Obviously possible differences due to exposure, surface cover, and shading should be determined, and duplicate or triplicate samples are desired as a rule. Practical difficulties in the way of repeated sampling of a small area and the size of the job itself will necessitate a compromise with the number of samples theoretically desirable.

Sampling from dug holes has been considered the only satisfactory procedure in the coarse granitic soils of the Experimental Forest, but geotome sampling will be tried out further. The latter would be preferable if it could be used, especially for the direct

seedbed samples where soil disturbance is objectionable.

(12) Soil.--Soil samples from depths of 0-½", 6", 12", and 18" (and at greater depths to the subsoil if necessary) from four points within each enclosure will be analyzed for mechanical composition, moisture equivalent, and reaction (pH). Selected or combined samples will be analyzed further for organic matter, nitrogen, potassium, phosphorus, and calcium. Sufficient additional determinations of moisture equivalent will be made from representative samples obtained later for moisture tests to establish usable averages and thus permit the computation of wilting coefficient and available moisture. (See further discussion of the "soil Factor", p.___).

(13) Root growth of seedlings.--The rate of root development has an important bearing upon reproduction problems, but this subject is largely included in the separate project of "Root Studies". In order to obtain a measure of root growth of the specific artificial plantings at the factor stations, representative specimens (5 (?) from each station) will be dug up once a week after germination for the

first month and monthly thereafter for measurement of total length and lateral development. A final or total measurement of root development may be obtained as suggested in section 9.

(14) Duration of study.--This phase of the study should be carried through two full seasons with fairly complete observations as outlined. It seems desirable to continue the measurement of survival and growth of seedlings under these semicontrolled conditions through their third growing season, but after the second year (1937) the number and intensity of observations can be greatly reduced. Some features of the study will thus carry over perhaps 5 years from date, but the major part of it should be completed in 1937. Preliminary and partial results should be available even after the first season.

The purpose of seedling beds #1 and #3 in each series--to test the influence of complete covering of the seed, such as might be done by logging, stock trampling, rodents, or rain washing--will probably be served by one season's study. Assuming that reasonably definite results are obtained, this phase may then be discontinued. It is

likely, however, that the desirability of studying the effect of some other variable will have appeared, so that no substantial reduction in total number of seedbeds and scope of experiment can be counted upon for the second year.

(15) Procedure in 1935.--Because of the late start in 1935, it seems undesirable to rush through the full installation of stations and try to make belated plantings as outlined. It is thus proposed through the coming summer to construct enclosures, prepare seedbed surfaces, set up instruments and make trial runs of all of them, develop record forms and technique, and modify this plan--in general, do everything possible to prepare for a definite and complete schedule of action beginning with planting this fall. It may even be possible to carry on certain measurements of site factors and of seedling survival using native or transplanted seedlings, which will contribute to the study.

(16) Equipment.--Most of the special instrumental equipment necessary for the study is now on hand. Materials for fencing, shade

frames, etc. will be purchased locally. An equipment and material list will be made up later as final plans develop. Local ponderosa pine seed of the 1934 crop is available.

Discussion: It is obvious that not all of the factors affecting natural reproduction are covered by this study and it may be questionable whether others may not be more important. It is therefore appropriate to mention the relation of these to some other factors and the reasons for not studying the latter specifically.

The influence of variable physical, chemical, and even biotic characteristics of the soil upon reproduction is undoubtedly important locally and is not covered by this study at all. Its importance may be less in this region than in some others, at least on the typical granitic soils that we are chiefly concerned with. The fact that in central Idaho there is no striking visible correlation of occurrence of pine reproduction with soil type suggests that the latter is not a major limiting factor. It may also be pointed out that with a given general soil type certain local soil differences are only a reflection

of exposure or topographic differences, of which we are obtaining some measure in this experiment. This is not to deny the possible importance of soil character, however, and it may appropriately be the subject of future study. Such soil determinations are prescribed in connection with this study are only for the purpose of avoiding spotted or "freakish" conditions and of providing a sound basis for weighting the soil factor in drawing conclusions.

The study does not adequately cover the great variations in soil surface (seedbed conditions) that influence germination and survival. It does strike at one major point of disagreement and uncertainty among past investigators--the effect of litter. It would be interesting to study burned or ash-covered soils (which were found by Fisher to give highest germination), perhaps the effect of color of soil upon actual losses, and numerous other possibilities, but it is necessary to hold the study within reasonable bounds.

The importance of the effect of competing vegetation (ground cover, brush, and trees) is recognized, but its manner and degree of

influence and even its net effect under various sets of conditions have not been established and are most difficult to determine by empirical observation. The present factor study, by practically excluding all vegetation, eliminates its infinite variations and complexities from the picture, but attempts to measure the effect of those direct factors of temperature, soil moisture, and light through which vegetation affects the seedling. It is hoped that with a better understanding of these basic relations and perhaps additional physical measurements under natural field conditions, the results of repeated observations on extensive transects (part IV of study) may be interpreted to formulate general conclusions on the role of competing vegetation. Actual planting tests under various intensities and forms of vegetation may be instituted as a check when time permits.

The effect of grazing upon reproduction has been the subject of study and observation since the early days of the Forest Service. It is believed there is satisfactory evidence that grazing which is sufficiently conservative and well controlled to prevent range depletion and erosion will have but little effect upon reproduction, except

where many young seedlings are just becoming established. We cannot say we have the final answer, but a further intensive study does not seem justified at this time.

The present study cannot be said to cover the influence of the larger climatic differences associated with altitude and geographic location, interesting and informative though such information would be. Probably the same experimental study of the three exposures and other variables provided for here would yield somewhat different results at the upper or the lower limit of ponderosa pine or in a moister or dryer locality. Results might also differ if the study were undertaken in another "phase of the climatic cycle"; a factor not to be overlooked and one to which Otter ascribes some of the contradictory results of past studies. As mentioned above, however, the present study should contribute basic information on relations to temperature, soil moisture, and insolation that should enable us to weight factors and to deduce conclusions applicable to a much wider range of climatic conditions than actually sampled.